Photo 5: The master bathroom back wall sample -MS (10-24-07) ■8- is located behind the sink on the back wall. There was visual observation of previous apparent mold growth on the cavity side paper facing of the gypsum wallboard. (A large section of the exterior wall was removed to discover the nature of the staining.) The cavity conditions were dry at the time of this inspection. The primary suspected cause of this historic moisture damage was a known plumbing failure and resulting flood that occurred behind the visible staining as reported by the owner. Healthy Homes sample location -(HHR 5-22-06) ✖3-.

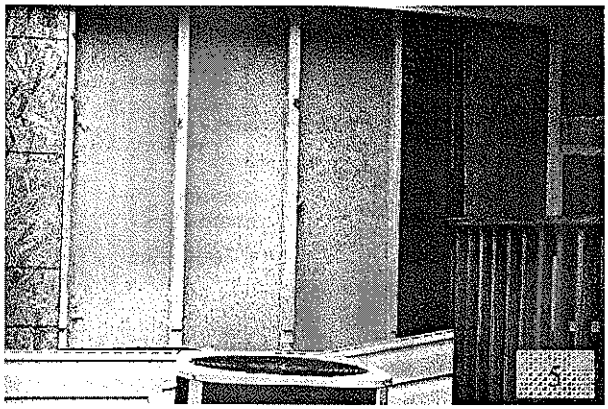


Photo 6: Red arrows point to observation of a distinct horizontal saturation line and area at the bottom of the wall cavity indicating that the leak was substantial enough to cause prolonged wetting of the gypsum wallboard and vertical wicking of standing water. It is not uncommon for flood damaged gypsum board to wick water up the entire height of the wallboard through capillary action.

Photo 7: This wall stud bay adjacent to the sink was reported as "soft"; however, this wall had been previously impacted resulting in an indention that broke the board and paper backing. This will allow the board to flex with the appearance of being soft.

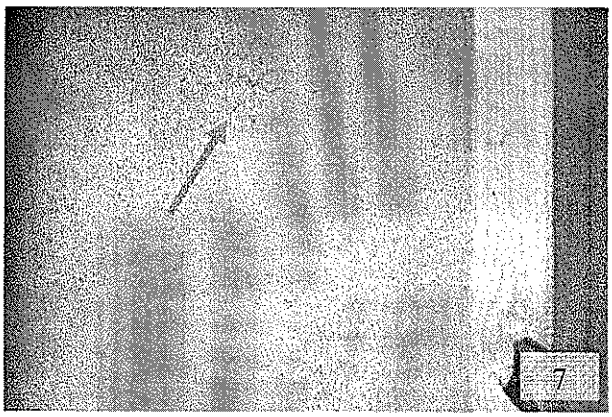


Photo 8: From inside the home damage to the wallboard is evident as a semi-rectangular impact. This wall is broken at this point and might appear to be soft. The impact indention that broke the board and paper backing is clearly visible.

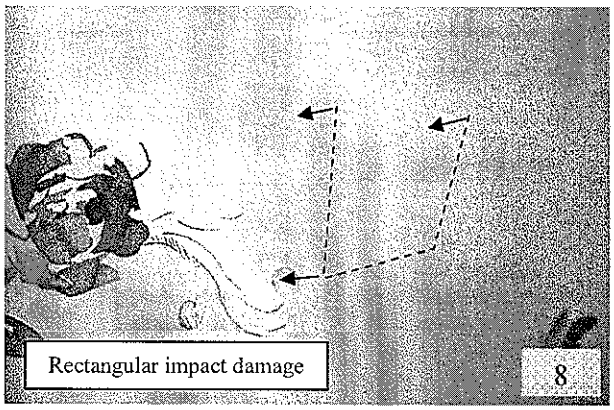
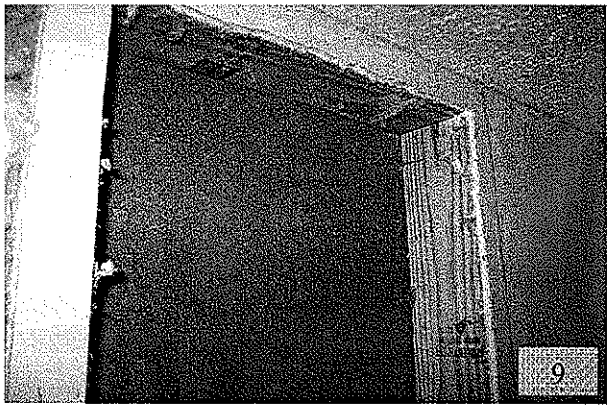


Photo 9: Samples of gypsum board cited as structurally damaged by HH were removed from the stud bay cavity from the end wall closet to be sent for structural testing. The interior of the stud wall cavity shows good practice in maintaining a substantially airtight wall cavity. No visible signs of damage were apparent; no signs of moisture, drip marks or possible fungal staining were evident.



Crawlspace Observations

An unusual earth berm and railroad tie configuration created by the homeowner place the exterior walls at risk of earth and rainwater contact that could result in capillary moisture intrusion into the wall cavity. Video taken during simulated rain demonstrates this risk of bulk water entry. It is clear that the rail road tie placement results in direct rainwater entry into the crawl space due to splash behind the railroad ties.

Due in part to the railroad tie water entry, the crawlspace is regularly saturated with moisture. Sampling results show that the crawlspace to be a significant reservoir of mold spores including Penicillium and Aspergillus.

The crawlspace moisture level is exacerbated by the fact that the exhaust vent for the clothes dryer discharges directly into the crawlspace area.

The crawlspace moisture level is exacerbated by the fact that the crawlspace ventilation strategy does not meet minimum specifications for cross ventilation and, is thus, not code compliant. This is an installation item – not a manufacturer's issue.

The crawlspace moisture level is exacerbated by the fact that bulk water apparently settles on top of the plastic ground cover – thus containing water under the home for long periods of time.

Photo 10: All exposed walls (except those under the front and rear porches) are at risk of bulk water intrusion into the crawlspace due to the unusual landscaping. Railroad ties directly adjacent to the exterior walls are observed to splash rain water into the crawlspace and also prevent proper minimum crawlspace ventilation.

Photo 11: At this location, the bottom plastic of the home was found with a cut along the exterior wall - apparently in order to install a water faucet on site. The moisture level in this part of the plastic is elevated compared to other locations. By turning a water hose on at the roof to simulate rain, it is apparent that significant water splashes behind the railroad tie and enters the crawlspace. Rainwater or hose water directed near this wall can easily splash into the floor cavity and dampen the area under the master bathroom sink.

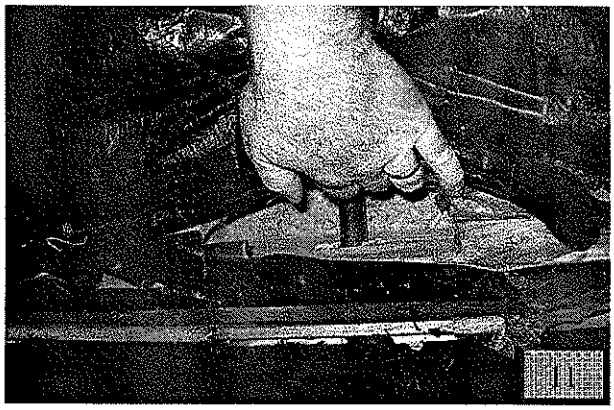


Photo 12: Splash from simulated rainwater shows how the railroad ties direct water under the home. The bottom plastic under the site-installed water faucet is torn allowing moisture to splash into the floor cavity area.

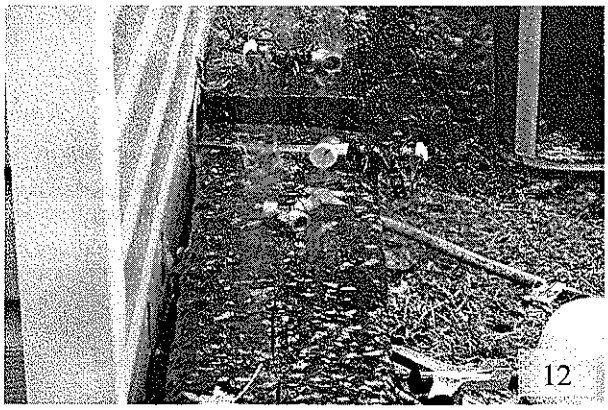
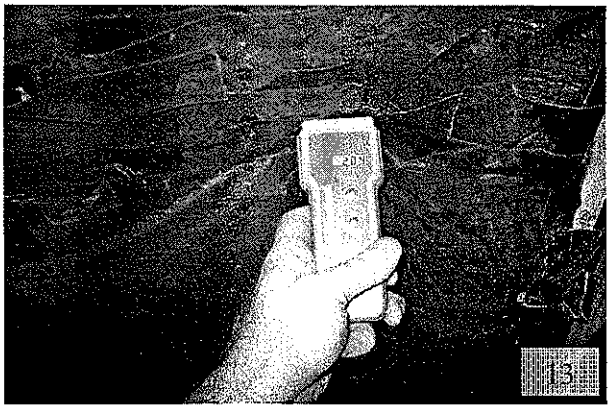


Photo 13: Moisture levels in the floor cavity insulation is higher (20% relative moisture level) than in other locations away from the splash area (10% relative moisture level).



Sketch for Photo 12 & 13: Schematic of Murphy landscaping detail; rail road tie sits atop a non-structural concrete block wall. Splash can enter the floor cavity and communicate with the wood structural members.

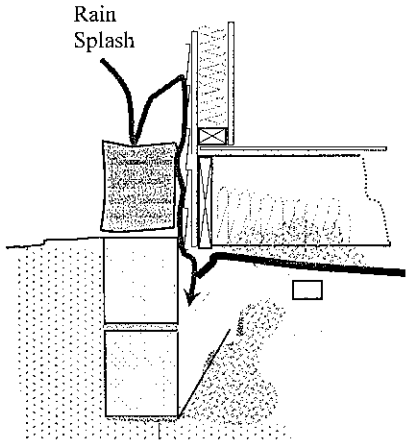


Photo 14: A pin meter shows wood moisture content of 18% in perimeter band joist under master bathroom sink area. This is a moisture management concern apparently resulting from splash into the floor cavity area. Such moisture will contribute to occasional elevated moisture in the master bathroom wall cavity.

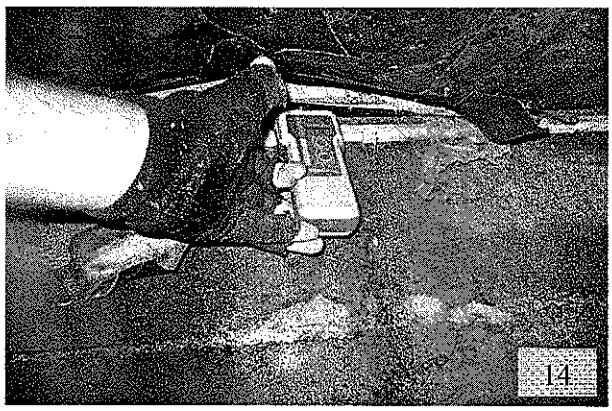


Photo 15: Water can be seen dripping in very close proximity to the torn bottom plastic near the faucet. Video taken of this shows the magnitude of water that splashes its way into the crawlspace at this location. This is the most likely explanation of elevated moisture levels in the insulation and surrounding floor timbers.

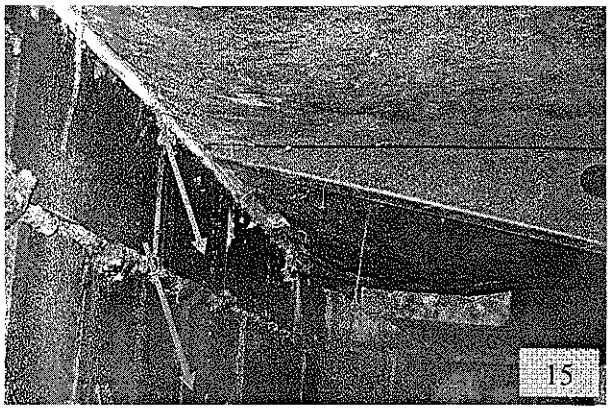


Photo 16: Heavy moisture stains throughout the crawlspace show that excess water entry is a persistent and long-term problem. Tan areas on black ground poly are mud sediment stains. White PVC drain pipe above is covered with suspected fungal stains.

Photo 17: Wood spacer block and wedge at support pier are heavily stained with apparent fungal growth. This is due to the poorly vented crawlspace foundation and the consistent entry of moisture through the foundation walls.

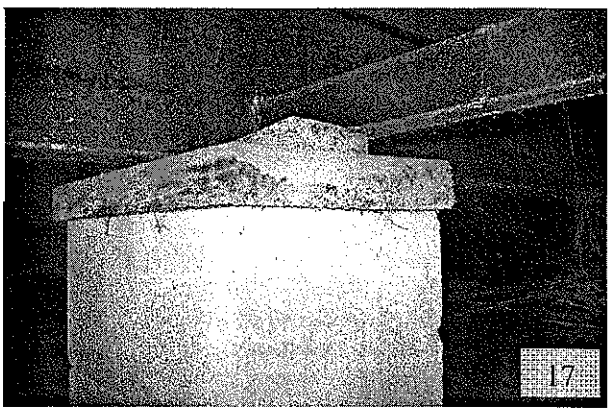


Photo 18: Exacerbating the wet condition in the crawlspace is the fact the dryer vent discharges directly into the center of the crawl space area.

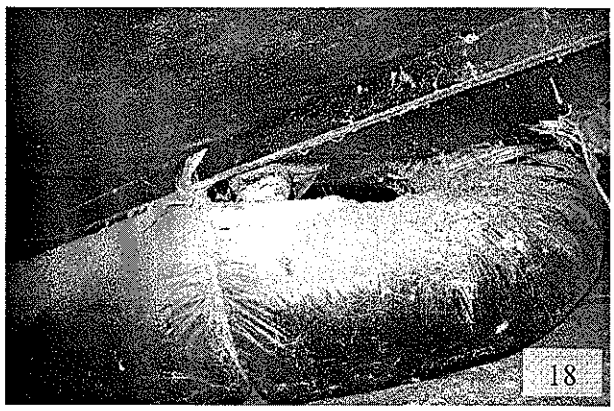


Photo 19: Front wall shows seepage through the block wall onto bare soil, creating excessive moist conditions in the crawlspace. Ground vapor plastic is not visible in this area.

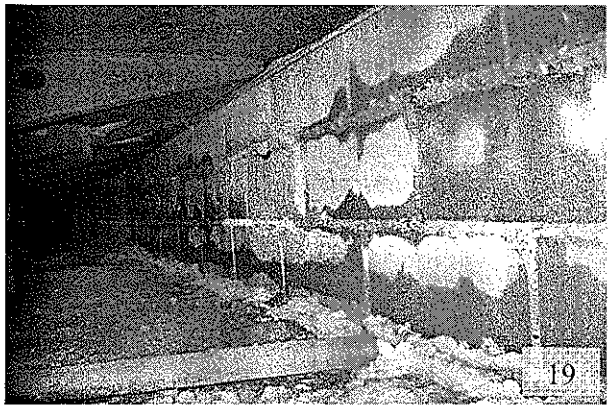


Photo 20: Crawlspace piers demonstrate stains from moisture moving up the block. This is further evidence of moisture in the crawlspace.

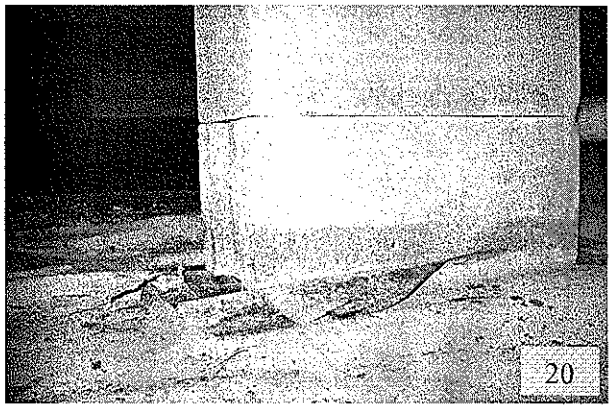
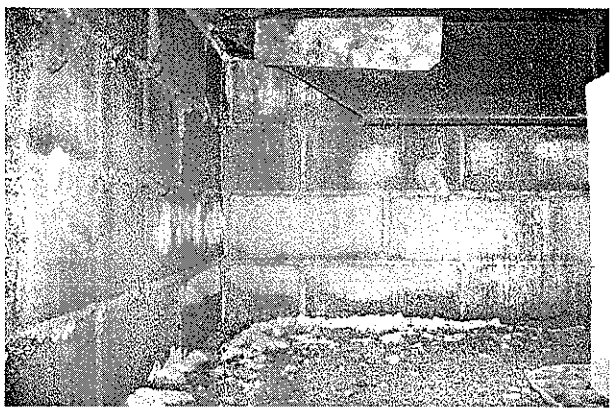


Photo 21: A small section of railroad tie has been removed to show the access into the crawlspace and the accumulated leaf litter and other debris.

Photo 22: Heavy moisture stains on the block wall throughout crawlspace show that this is a persistent and long term problem.

Photo23: The soil under the master bathroom adjacent to the rear wall is fully saturated.



Heating, Ventilation and Air Conditioning Observations

The Heating, Ventilation and Air Conditioning (HVAC) system was inspected visually. Cooling is provided by a 2 ½-Ton, 10-SEER split-system air conditioner. According to the MHRA Cooling Equipment Sizing Guidelines[27] the air conditioner is properly sized. In terms of duct leakage and system pressure management, this home represents best practice performance.
There were multiple observations that indicated a lack of regular HVAC maintenance and installation issues as follows.

- The filters were dirty and the A/C coils needed to be cleaned. There were significant deposits of dust and debris on the heating coils and within the furnace cabinet.
- Rust and water stains in the furnace cabinet indicate past condensate backups and overflows. Air conditioning condensate backup problems are strongly associated with causing excess humidity conditions in homes.
- As installed, refrigerant pipe penetrations through the furnace cabinet were not air sealed.

Except for the external crossover duct, ducts in a double-section home are considered to be located within the intended air barrier of the home that is created by the bottom plastic. When this bottom plastic is properly maintained, air leaking from ducts is normally redirected back into the home without negative consequences.

Duct leakage to outside was measured and found to be 27CFM25 to outside. This is less than a "2%" leakage rate and places this home in the best practice category for duct integrity.

The leakage rate of the building envelope as defined by a blower door test was found to be1470 CFM50. This is a superior level for a 1530 square foot home; this number can be converted to an estimated annual estimated air change per hour of 0.28. Such a home should consider a fresh air ventilation system as this home has.

Building pressures were measured using a normalized reference pressure to minimize the effects of wind on the pressure measurement.[28] Pressure when the air handler was engaged the "system pressure" did not produce a measurable pressure difference.

Fresh air ventilation is provided by a make up air duct that brings outdoor air to the return plenum above the furnace blower. Although the ventilation air intake is curved and not directly connected to the air conditioner A-Coil as is recommended by the equipment manufacturer, because airflow in the duct is low, the bend will have little impact on actual airflow and ventilation airflow will still be to the inside of the home. Observations showed that outdoor air was being delivered through the ventilation duct when the furnace fan was engaged. Regardless, proper placement of the fresh air ventilation intake is the responsibility of the air conditioner installer – not the manufacturer.

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[27] Manufactured Home Cooling Equipment Sizing Guidelines, Manufactured Housing Research Alliance, 2005. www.mhrahome.org These sizing guidelines are a county-by-county cooling equipment capacity size recommendations calculated by Wrightsoft Corporation based on ACCA Manual J Load calculations.

[28] A normalized reference pressures is obtained by taking pressures from more than one location – in this case the outside reference pressures were taken from both the front and the back exterior side of the home and combined to one hose. Normalized reference pressures minimize errors in house pressure measurements often seen due to wind.

Photo 24: The A/C coil needs cleaning; other photos support that the HVAC equipment is not adequately maintained.

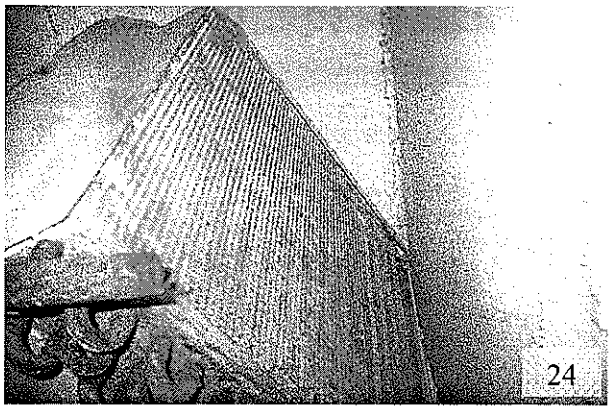


Photo 25: Rust stains below the condensate pan indicate past condensate overflows.

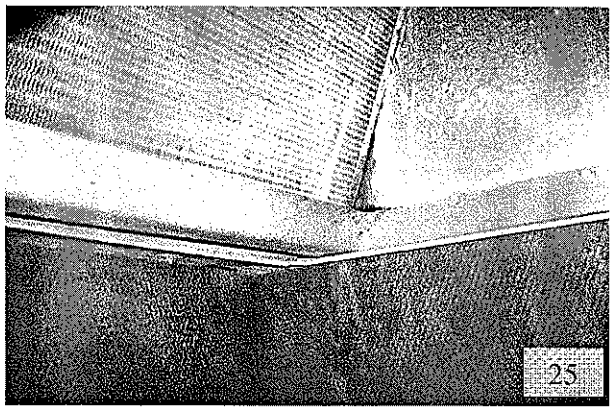


Photo 26: Water stains inside of the furnace cabinet indicate past condensate overflows.

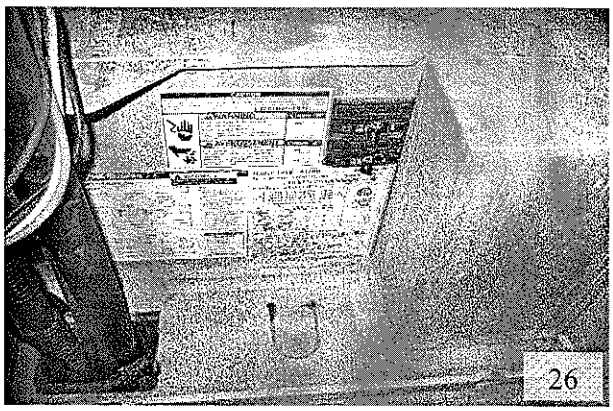


Photo 27: Sediment and water stains at the bottom of the furnace cabinet indicate past condensate overflows.

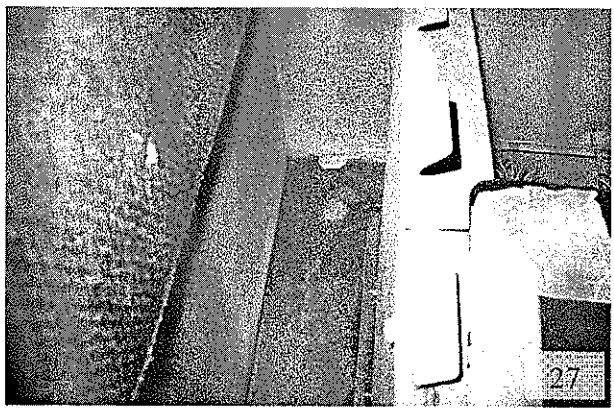


Photo 28: Pressure when the air handler was engaged the "system pressure" did not produce a negative pressure effect; rather the air handler had a neutral effect on the house pressures.

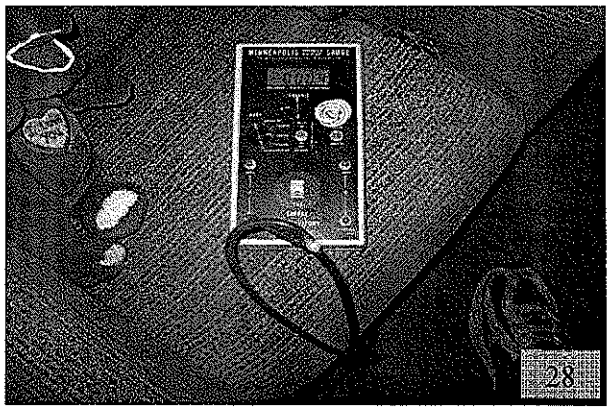
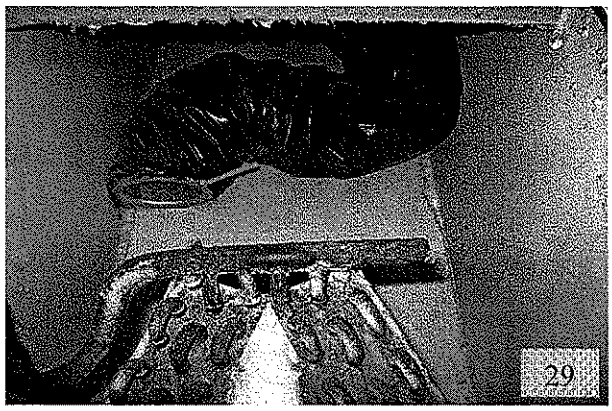


Photo 29: Fresh air ventilation is provided by a make up air duct that brings outdoor air to the return plenum above the furnace. The installation of the duct was acceptable; the extra curve in the flex duct will not result in significant flow reduction at the expected airflow. Observations showed that outdoor air was delivered through the ventilation duct when the furnace fan was engaged.



Infrared Imaging Observations

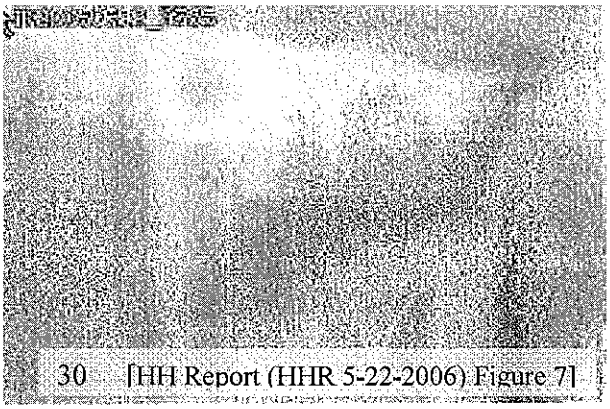
Thermal imaging (IR) cameras show surface temperatures as different colors and are sometimes used in building diagnostics.

Photo 30: The HH Murphy home report indicates that the red color is an indication of "air/heat infiltration." This is a normal and expected image seen in any light frame construction where IR photos are taken during the daylight hours when sunlight can impact the images and confuse interpretation.

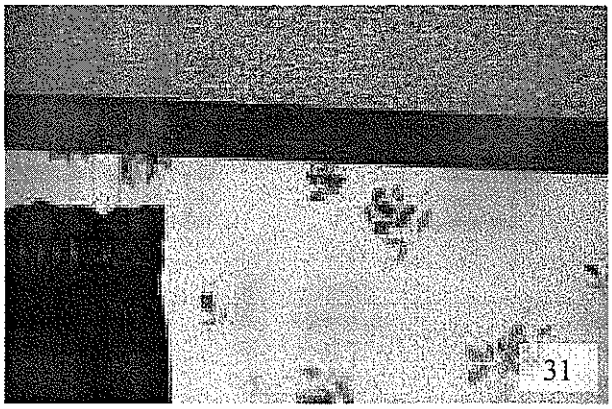
The HH infrared images from the Murphy home were taken outside guidelines provided by ASTM inspection protocols and are thus subject to misinterpretation. Two ASTM standards are commonly used to provide a consistent protocol for IR investigations – one protocol recommends images be taken only after 3 hours without sunlight, the other requires a series of photos before and after operation of a calibrated whole house fan – neither of these protocols were followed.

There is no way to tell by the thermal images provided by HH whether any "air/heat infiltration is taking place within the wall cavities as is claimed. The temperature differences could have easily been caused solely by heat conduction from outside and insulation imperfections. It is improper to make the assumption that there is any indication of "air/heat infiltration" in this area as was reported in the Healthy Homes report.

Photo 31 & 32 reflect thermal bridging, where the more conductive wall top plate is conducting heat outwards. (This is a cold weather picture – thus the blue color represents heat loss.) The two superimposed images illustrated in Photo 32 show that the temperature differences between the blue and red colors is only 1.3°F; and in spite of the dramatic color variation is not significant.



30 [HH Report (HHR 5-22-2006) Figure 7]



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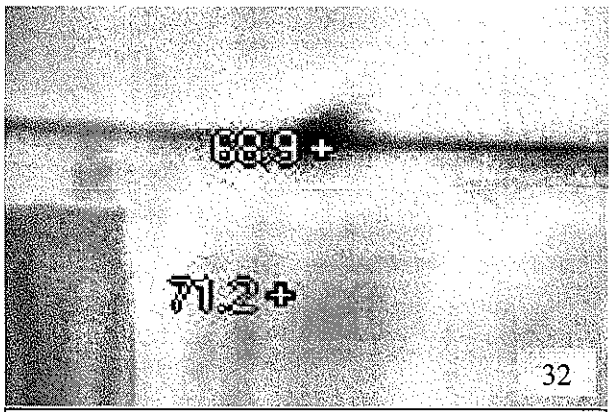


32

Neither ASTM IR monitoring protocols and guidelines were followed in the HH analysis of the Murphy Home; making it improper to draw scientific conclusions from these images.

ASTM C- 1060-90 Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings,

ASTM E 1186-03: Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems

Roof Observations

During my (MS 10-24-07) visit, I conducted a brief visual and infrared inspection of the roof. The shingles appeared to be in relatively good condition. No unusual bowing or sagging of the decking or other imperfections was observed.

The sealing around almost all of the roof penetrations is beginning to deteriorate. Roof penetrations and flashings are typically required by the homeowner manual to receive periodic (annual) inspection and re-sealing. This 4-year home appears only to have the original factory sealing material, and maintenance/resealing should be provided. Delay of routine maintenance could result in water damage to the roof assembly and adjacent building components.

Photos 33 & 34: The sealing around almost all of the roof penetrations is beginning to deteriorate. This 4-year home appears only to have the original factory sealing material, and maintenance/resealing appears to be over due.

Moisture meter measurements and observations

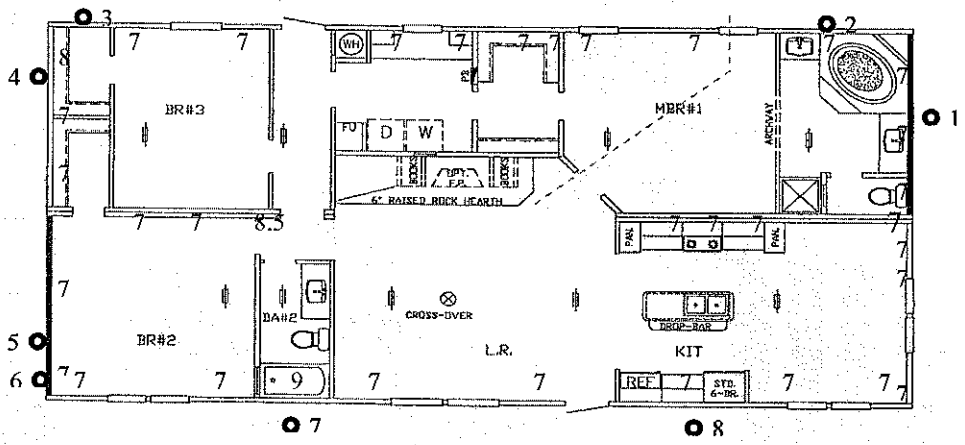
A series of moisture readings from a variety of meter types were taken for both the gypsum wallboard and for the wood framing throughout exterior wall cavity inspection sites. Moisture meter readings for gypsum are only valid as relative measurements – even though the Delmhorst meter attempts to convert pin readings for gypsum into percent moisture content – this is not considered to be very accurate and should also be read as a relative measurement. Moisture meter readings for wood are considered valid for clear yellow pine and values are expressed in percent moisture content. In general, all wall cavity moisture readings were low and normal for this climate, and all wood framing members were solid, clean and in like-new pristine condition. Some of the wood members were difficult to measure with the pin meters (a hammer electrode would be needed to force the pins into the wood, and this was not available); also the meters did not always easily fit into the small access holes, and when they could, the reading could not always be photographed. None of the readings for the wood frame members was higher than 8.5% MC. A table below summarizes typical measurements; A series of photographs supporting the table follows.

A series of moisture readings was taken from the interior of the home using the Wagner meter. Although the Wagner meter is calibrated for wood moisture equivalent, because only relative values are meaningful for gypsum wallboard, such a meter is suitable for this purpose. All relative moisture levels on the exterior walls were low (less than 8% relative) and were equal to the moisture level on the interior walls.

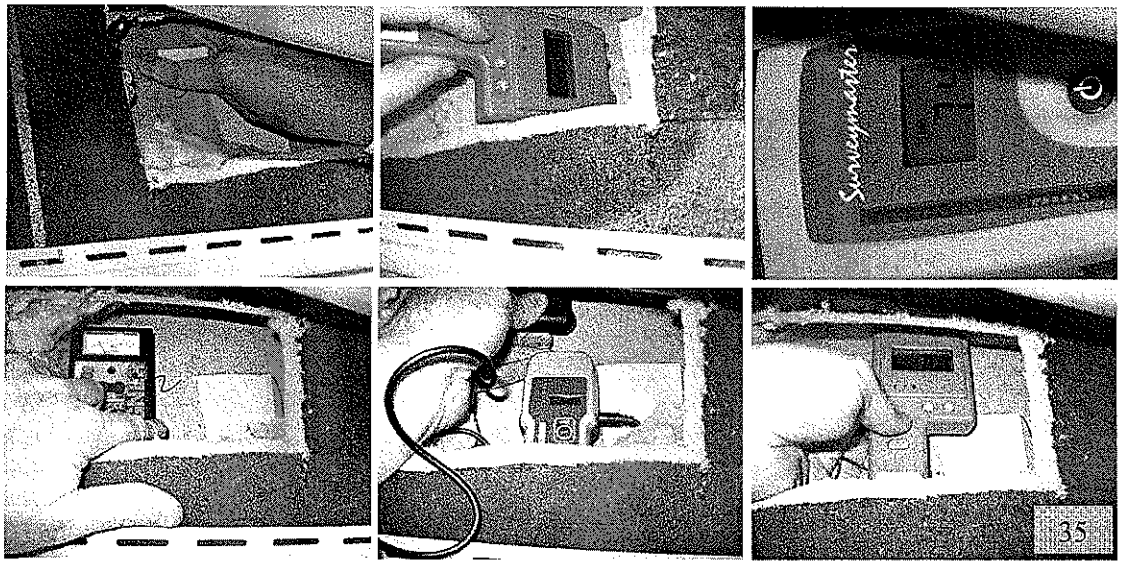
Table 1: Wall Cavity Moisture Meter Readings for Gypsum Wallboard and Wood Frame - Murphy Home

	Gypsum Wallboard					Wood Frame - Pin	
Wall Cavity Site	Delmhorst BD-2100	Protimeter Surveymaster	Wagner L606	Protimeter SM (New)		Delmhorst BD-2100	Protimeter Surveymaster
2	0.1 (pin)	-	<8%	7.4		8.0	8.0
3	0.2 (pin)	7.4	<8%	1.0		-	7.4
4	0.2 (pin)	8.7	<8%	8.5		8.5	-
5	0.1 (pin)	9.0	<8%	8.1		-	-
7	0.2 (pin)	-	<8%	8.5		-	8.2
	"Calibrated" for gypsum %MC	Relative Value	Wood Moisture Equivalent	Relative Value		% Moisture Content	% Moisture Content

Figure 5. O Wall cavity sample locations for moisture level readings.
7, etc. Relative moisture readings from inside home



Wall Cavity Inspection Site 2



Wall Cavity Inspection Site 3